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Effect of Injection Pressure on Vibration Performance of IC Engine by using Diesel-Biodiesel Fuel

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ABSTRACT

Recent scenario says that traditional fossil fuels are depleting day by day. The environmental pollution issues also arise globally. Hence alternative fuels are the need of the hour now. Biodiesel comes forward as the best alternative fuel because it can be used directly without any modification to diesel engine up to a certain level. Currently, 20 % biodiesel blend with 80% diesel is used. But bio diesel has certain limitations such as high viscosity, high density, and lower calorific values. These limitations restrict the blending percentage of biodiesel with diesel. To overcome these limitations, many researches recommended modifications in injection parameter. But all these studies focused on emission and performance only. In this experimental study, vibration performance analysis of the diesel engine was carried out by using different fuel blends and varying injection pressures. Experiments were performed on a single cylinder diesel engine using two Jatropha biodiesel blends, three different Injection pressures. Injection pressure was set at 130, 170 and 210 bar Experimental study shows that fuel injection pressure significantly effect on engine vibration.

Keywords : Diesel Engine, Vibration, Fuel blends, Injection Pressure, Injection Timing

I. INTRODUCTION

Development in the field of automobile field and industrialization, demand of fossil fuels increased tremendously. Due to the overuse of fossil fuels, environmental problems arise. Also, increased fuel prices & strict emission standards lead towards alternative fuels. Biodiesel is a best suitable option for the fossil fuels. Due to increased demand lots of researches are going on biodiesel and its suitability to a diesel engine. Currently, 20% biodiesel is used in diesel engine without any modifications to the engine. Research studies till date show that with some modification to engine, fuel blending may be increased. Many research studies were carried out in the area of performance and emissions analysis. Effects of biodiesel on engine vibration performance still not reported so far. Vibration analysis of biodiesel engine can give idea about probable harm to the engine due to inappropriate combustion.

Rudolf Diesel presented an engine based on compression ignition diesel engine. Rudolf Diesel suggested that a diesel engine can be fed by vegetable oil and this possibility could help agriculture development. [1] Biodiesel is mixed with diesel fuel and then used in combustion engines. One of advantage of biodiesel is its less pollution in comparison with Diesel fuels. [2]

Biodiesel can be used directly with diesel engine without any significant modification. But biodiesel have certain limitations. Amin Maghbouli et al. [3] examined that the physical ignition delay increase by using bio-diesel or its blend with diesel fuel. This is due to high kinematic viscosity and surface tension of the biodiesel which causes longer fuel droplet evaporation. Such a change in fuel thermo-physical properties, break up, atomization and evaporation of bio-diesel fuels take longer time. This may effect on engine combustion and emission characteristics. Hence, injection strategies are much more important in bio-diesel driven engines comparing to a diesel

The present design and operating conditions of the diesel engine are designed only for diesel fuel. Change in fuel requires change in injection parameters according to fuel properties. Balaji Mohan et al. [4] reviewed the researches in the area of fuel injection parameters for performance improvement and emission reduction in IC engine. Increase in injection pressure results in smaller droplet size and large no. of droplets. It results in improved performance.

A. P. Carlucci et al. [5] stated that fuel type and injection strategies have a greater effect on combustion process. This may cause for engine vibrations. So, performance and emission are not the only criteria for fuel and Injection strategy selection but Vibration level also.

Y.Ashok Kumar Reddy and B.V. Rao [6] investigated and stated that the uneven and unreliable combustion inside the combustion chamber results in knocking leading to erosion and harm to the combustion chamber and piston head. Seyed Vahid Mirnezami et al. [7] investigated the effect of vibration on human. Sound and vibration resulting from combustion engine have direct affect on users. Diesel engine used in agriculture equipment such power tiller direct effect on the wrist and arm of the operator.

In this study, vibration performance of single cylinder diesel engine is aimed. Jatropha biodiesel blends B20 and B40 are used. Injection pressure is modified. Vibration is measured by using accelerometer. Root mean square values of acceleration are used for vibration level comparison.

II. METHODS AND MATERIAL

A. Biodiesel and its blends

Biodiesel is nonpolluting fuel made from organic oils. It is chemically called as free fatty acid methyl ester. Biodiesel is obtained from organic oil and fats after transesterification. Organic oil is of two types, Edible oil and non-edible oils.

In present study, non-edible oil was used. Non edible oil was preferred due to price of production and possible shortage of edible oil. Jatropha Methyl ester oil blended with diesel. B20 (20% biodiesel, 80% diesel) and B40 (40% biodiesel, 60% diesel) were used.

Biodiesel blends purchased from SVM Agro Processor, Nagpur. Fuel properties testing were carried out at Nikhil Analytical Laboratory, Sangli. TABLE I show properties of diesel and biodiesel fuel used for experiment.

TABLE I
PROPERTIES OF DIESEL AND BIODIESEL

Sr. No	Property	Unit	Diesel	B20	B40
1	Density	kg/m^3	805.1	817.0	836.6
2	Viscosity	cSt	01.14	1.33	02.23
3	Cetane Number	-	48	49	50
4	G.C.V	kcal/kg	9981	9635	

B. Engine Specification

In present study, single cylinder diesel engine of Kirloskar make was used. Engine setup was available at RIT, Islampur. The technical specification of engine showed in TABLE II

TABLE II
TECHNICAL SPECIFICATION OF ENGINE

Engine Parameter	Specification
Engine Manufacturer	Kirloskar TV1
Number of cylinder	1
Power	5.2 Kw
Speed	1500 rpm
Method of cooling	Water cooled
Compression Ratio	17.5:1
Injection timing	23^0bTDC

The experimental study was carried out on single cylinder diesel engine. A Kirloskar make water cooled engine was coupled with eddy current dynamometer.

Vibration measurement was carried out by using single axis accelerometer of make Bruel & Kjaer. The frequency range of accelerometer was 0 to 12800 Hz. And operating temperature was -55°C to 125°C

For vibration signal recording and signal processing, Bruel & Kjaer FFT analyzer was used. A Fig.1 shows experiment setup for engine and vibration measurement system.

Figure 1. Experimental Setup

C. Engine Injection Pressure Modification

In present experimental study, to investigate the effect of fuel injection strategies on biodiesel engine vibration performance, modifications to injection pressure has been done.

Injection pressure was changed by changing injector spring tension. Initially pressure was at 170 bar. Then it was modified to 130 bar and 210 bar. Fig. 2 shows a Bosch make fuel injector of diesel engine. The modified injector was calibrated on Injector Pressure Calibration POP tester at Bosch Service center.

Figure 2. Bosch fuel injector

D. Experimental Procedure

The experimental work started with standard engine setting, injection pressure at 170 bar and injection timing of 23ºbTDC. Initially diesel was used as fuel. Then injection pressure varied to 130 bar and 210 bar. After that, fuel was altered with B20 and test conducted for three injection pressure. Same procedure was carried out for B40 fuel blend.

Vibration measurement carried out by using accelerometer. Accelerometer used in this study was a single axis accelerometer. Vibration of engine was measured at three different locations viz. top of cylinder head, front of cylinder block and side of cylinder block. Bruel & Kjaer FFT analyzer and PULSE Labshop software was used for data recording and data processing.

III. RESULTS AND DISCUSSION

In present study, vibration performance of single cylinder engine is analyzed by using different fuel injection pressure and with different fuel blends. Effect of injection pressure on engine vibration was determined. Also effect of fuel blends on engine vibration performance was determined.

In case of Diesel, Overall vibration acceleration RMS value was 89.4 m/s2 at 130 bar while at 170 bar and 210 bar, it was 92.45 m/s2 and 97.2 m/s2 respectively. Same trend was observed in case of B20 blend and B40 blend.

With decrease in injection pressure, reduction in vibration was observed while with increasing injection pressure, increment in vibration was observed. Hence for any fuel blends, lower injection pressure gives low vibration into engine while higher injection pressure gives high vibration level.

Increasing injection pressure causes to improved atomization of diesel and better fuel- air mixing. Ignition delay period is minimized. This results in proper and complete combustion but in actual due to smaller droplet size and large number of droplet, rapid burning takes place. Due to rapid burning rate. Rapid gas pressure takes place in side combustion chamber. Heat release rate and pressure rise increase in high injection pressure. Hence vibration increases with high injection pressure.

TABLE IV
VIBRATION LEVEL COMPARISON

Injection Timing	Injection Pressure	Fuel blend	Vibration acceleration

^{0}bTDC	Bar		RMS m/s2
23	130	Diesel	89.4
23	130	B20	81.99
23	130	B40	78.84
23	170	Diesel	92.45
23	170	B20	87.27
23	170	B40	85.24
23	210	Diesel	97.2
23	210	B20	91.86
23	210	B40	89.32

Considering the fuel blends, B20 blend has less vibration than other fuel blends. B20 blend has less vibration at any injection pressure than other. Biodiesel has higher cetane number which cause for low vibration.

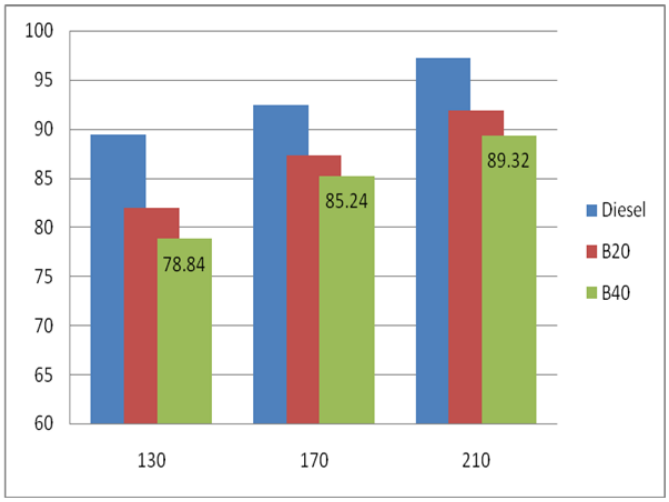

Figure -3(a): Effect of injection pressure on vibration level

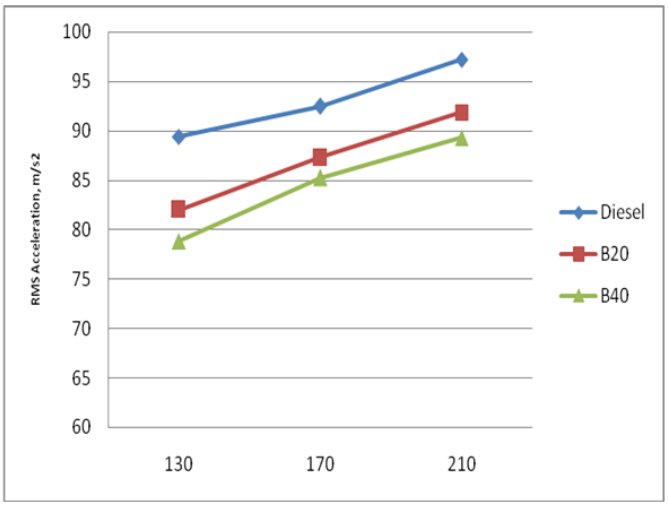

Figure -3(b): Effect of injection pressure on vibration level

Fig. 3 (a) and (b) shows graphs for vibration levels at three injection pressures.

IV. CONCLUSION

Present study was carried out for vibration measurement of diesel engine with different fuel blends and different injection pressure. Study was aimed to investigate effect of fuel injection pressure on IC engine vibration. Result obtained show that lower injection pressure gives low vibration. While high injection pressure cause to increased vibration level. In another observation, B40 blend has low vibration at any injection pressure than other two fuels.

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